Universidad Europea

GRADUATION PROJECT

Degree in Dentistry

TISSUE REACTIONS TO VARIOUS SUTURE MATERIALS USED IN ORAL SURGICAL INTERVENTIONS

Madrid, academic year 2022/2023

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ABSTRACT AND KEYWORDS

Introduction: Suturing is one of the main techniques performed in most dental surgeries. Nowadays, black silk is the most widely used suture because it is cheap and easy to use clinically. We need to evaluate its effectiveness. **Objectives**: The main objective was to establish the best suture materials in gingival surgery for an esthetic result and to minimize the tissue reaction. To develop, we used secondary objectives as follow: to compare the tissue reaction between monofilament and multifilament, find the ideal diameter of the suture as well as the needle appropriated for each procedure. **Material and Method**: With our research question a literature review was carried out through MEDLINE complete and Google scholar. The research was limited to full articles published since 2013. **Results**: Applying the established inclusion and exclusion criteria, a total of 44 studies were included in the review. **Conclusions**: Black silk should not be the main suturing material in dentistry, due to its natural multifilament structure, it is more susceptible for plaque accumulation and inflammation of adjacent tissues. More recent studies suggest using monofilament synthetics material such as Nylon or multifilament synthetic as the Polyglactin, to minimize tissue reaction and avoid scarring. The ideal suture diameter is always the thinnest possible compared to the strength and thickness of the tissue. The more commonly used are diameter 4-0 in the oral cavity. Finally, the needle should pass through the tissue but not tear it. The more used are the triangular “reverse cutting” needles. Due to the narrow arreas, we need to use curved needles in the oral cavity. The ideal curvature is 3/8 of a circle because it has more maneuverability and good penetration with just a swing wrist movement from buccal to lingual or palatal.

Dentistry; Suture materials; Tissue reaction; Scars; Suture diameter

RESUMEN Y PALABRAS CLAVE

Introducción: Suturar es una de las principales técnicas que se realiza en la mayoría de las cirugías dentales. Actualmente, la seda negra es la sutura más utilizada porque es económica de y uso clínico fácil. Necesitamos evaluar su eficacia. **Objetivos:** El objetivo principal fue establecer los mejores materiales de sutura en cirugía gingival para un resultado estético y minimizar la reacción tisular. Se utilizaron como objetivos secundarios los siguientes: comparar la reacción tisular entre monofilamento y multifilamento, encontrar el diámetro ideal de sutura, así como la aguja adecuada para cada procedimiento. **Material y Método:** Con nuestra pregunta de investigación se realizó una revisión bibliográfica con MEDLINE complete y Google académico. La investigación se limitó a artículos completos publicados desde 2013. **Resultados:** Aplicando los criterios de inclusión y exclusión establecidos, se obtuvieron un total de 44 estudios fueron incluidos en la revisión. **Conclusiones:** La seda negra no debería ser el principal material para suturar en odontología, debido a su estructura de multifilamento natural, es más susceptible a la acumulación de placa y la inflamación de los tejidos adyacentes. Estudios más recientes sugieren utilizar material sintético monofilamento como el Nylon o multifilamento sintético como la Poliglactina, para reducir al máximo la reacción del tejido y no producir cicatrices. El diámetro de sutura ideal es siempre el más fino posible en comparación con la resistencia y el grosor del tejido. Los más utilizados son el diámetro 4-0 en la cavidad bucal. Finalmente, la aguja debe atravesar el tejido sin rasgarlo. Las más utilizadas son las agujas triangulares “reverse cutting”. Debido al a las áreas estrechas, necesitamos usar agujas curvas en la cavidad bucal. La curvatura ideal es el 3/8 de círculo porque tiene más maniobrabilidad y una buena penetración con solo un movimiento oscilante de la muñeca de vestibular hasta lingual o palatino.

Odontología; material de sutura; reacción de tejido; cicatrices; diámetro de la sutura

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1. INTRODUCTION

1.1 Introduction to suture thread

A suture, word coming from the Latin sutura or suere - to sew- is a surgical act that restores the continuity of separated tissue or organ through sewing and that result in approximate tissues (1). In most of oral surgery, a flap need to be performed. After the treatment have been correctly performed, the wound need to be sutured by primary intention (2). Thus, dental suturing's main goal is to maintain surgical flaps securely to favors optimal healing, to support tissue margins while they heal to avoid dead space, and to lessen postoperative discomfort. Flap skipping, exposed bone or necrosis, pain, and a delay in wound healing can all be consequences of inadequate or improper suturing (3). The term "suture" also refers to the medical equipment, the material, that allows this act to be performed and is define as a needle-mounted sterile thread used in surgery to sew two separated tissues (4). A large variety of thread materials are available for this purpose and can be split by their origin: natural or synthetic (*Figure 1* line in blue) , or by the time they will last in the host tissues (*Figure 1* line in purple): absorbable and nonabsorbable (1, 3 , 5).

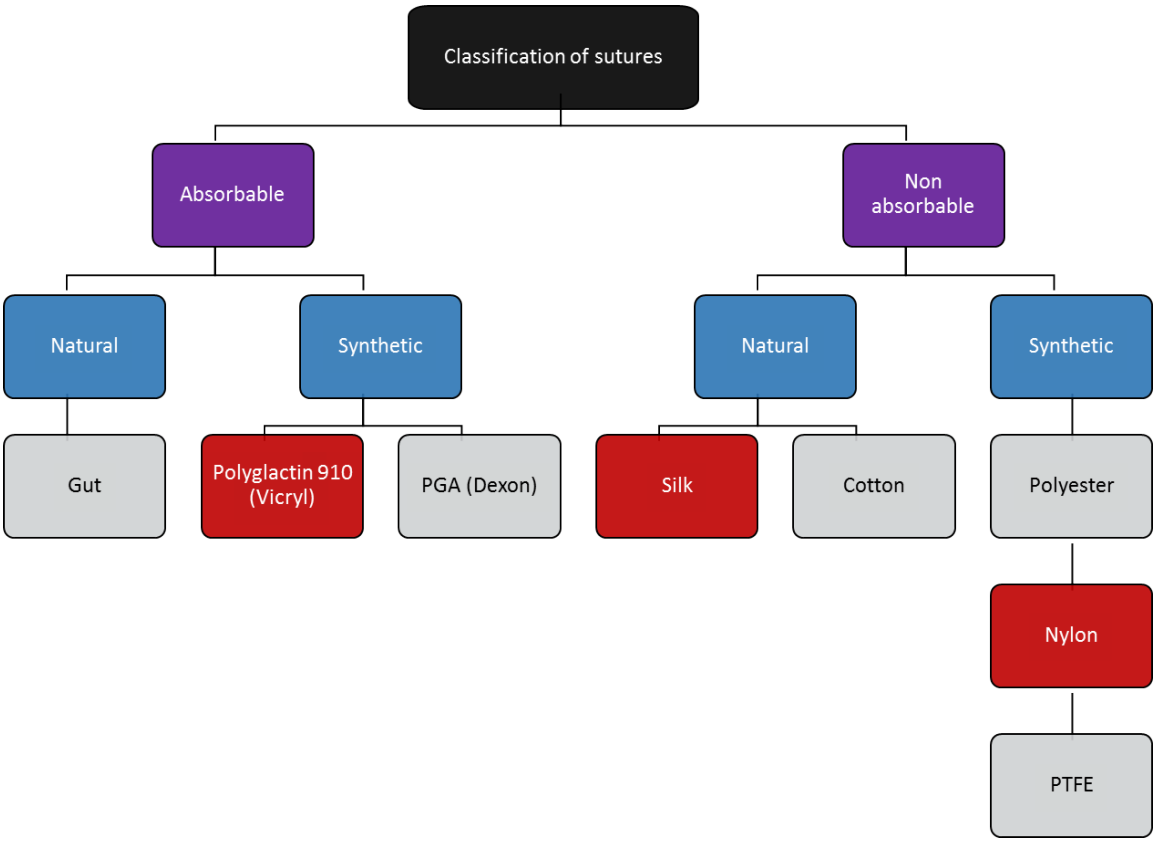
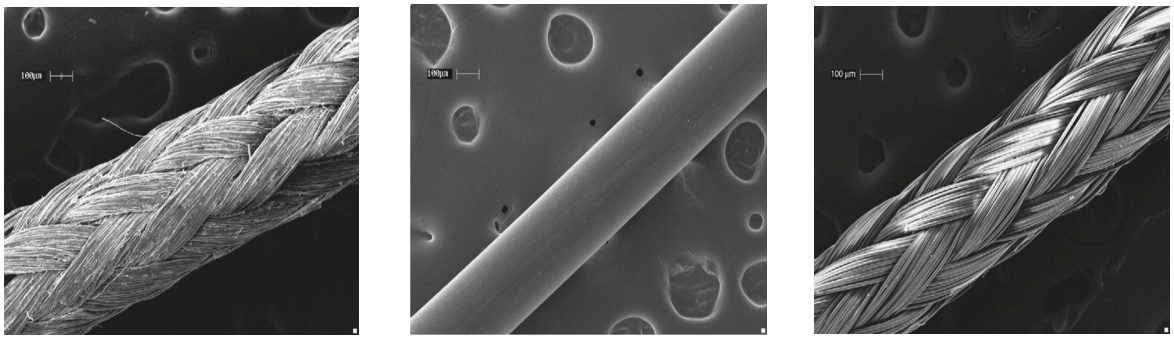


Figure 1. Classification of suture materials based on their origin (in blue), their physical property (in purple) and the material that we will detail are in red : one for each family still in use nowadays (3).

The absorbable sutures are deteriorated by the body with hydrolysis or an enzymatic reaction. This reaction can take from 14 to 90 days to be completed (3, 7). On the other hand, the nonabsorbable sutures resist in the body environment a long time without any changes. They are used in some area that take a long time to heal or when we want to have a second intervention to remove the suture and follow the correct healing of the tissues around it (1). The nonabsorbable can be either made of natural fibers as the silk or synthetic as the nylon. Those last two can also be distinguished by their microscopical structure: the nylon is a monofilament, a single stranded thread whereas the silk can be monofilament or multifilament, made of several fine filament twisted together as a braided cord, to form the suture thread (1, 5).



(A) (B) (C)

Figure 2. Electron microscopic pictures of two common nonabsorbable sutures: (A) Silk, (B) Nylon (Ethilon) and one absorbable suture: (C) Polyglactin 910 (8).

Each structure has its own propriety that can be an advantage or an inconvenient: In fact, monofilament pass steadily through tissue, but knots are loose. Braided sutures may not cross smoothly but knot well (5). The last parameters to take in account when selecting the appropriate suture thread for each oral surgery is the suture diameter. In fact, the diameter of the thread affects the tensile strength of the suture as well as the ease of handling. The tensile strength of a suture is the strength (in mg or pounds) that

it can resist before cracking (9). When sutures were first manufactured in the 20th century, size 1 was assigned to the smallest initially available. Successively, as the production and machines evolved, the sutures that were made with a smaller diameter were referred to as sizes 0 then 00 (2/0 or 2-0), 000 (3/0 or 3-0), and so on. According to the United States Pharmacopeia (USP) and EP (European Pharmacopeia), modern surgery sutures come in sizes ranging from 10 (almost never used in clinic) to 11-0 (delicate monofilament sutures for ophthalmic surgery under microscope) (5). The higher the number of zeros, the smaller the size and the lower the strength of the tread (3). For example, 3-0 suture has a diameter that is about 3 to 4 times bigger than 6-0 suture (5). The sutures used in the oral cavity are either 3-0 or 4-0 in the tongue and 4-0 or 5-0 for the intraoral mucosa. In relation with the natural strength of the tissue to be sutured, the smallest size possible should be chosen. The surgeon's choice of suture size and tensile strength is dependent on the tissue's own tensile strength. Most experts agree that the suture's tensile strength should be minimum as strong as the tissue it sutures, and ideally it should be higher. The initial resistance, which must not be confused with the resistance after a few weeks of implantation in the organism (in vivo), also depends on the material of the suture and his characteristics (resorbable or not) (9).

1.2 Introduction to suture needle

The needle is the second component of the suture. It allows the suture to be placed inside the tissue, passing through it with little residual trauma. The needle is made up of 3 sections: tip, body and swage (3). The ideal surgical needle should be stable inside a needle holder to enable an accurate placement, rigid enough to resist distortion but also flexible enough to bend a little without breaking in the tissue. It should also be as thin as possible to minimize injury (10). It is generally made of stainless steel nowadays and his cross section as well as it shape can vary in a large way. The shape is described (*Figure 3A*) as the curvature using the proportion of a complete circle, the ¼, ⅜, ½, and ⅝ are the most commonly used (5) . Different shape are needed depending on the access to the area to suture (10). The cross section depends of the tissue to be sutured, in gingiva we use cutting point needle with reverse cutting triangular cross section or the

taper cut needle which have a triangular point and a round cross section in the body of the needle (*Figure3B*). The last one allows to avoid cutting more tissue structures once the needle is passed through the tissue (5, 10).

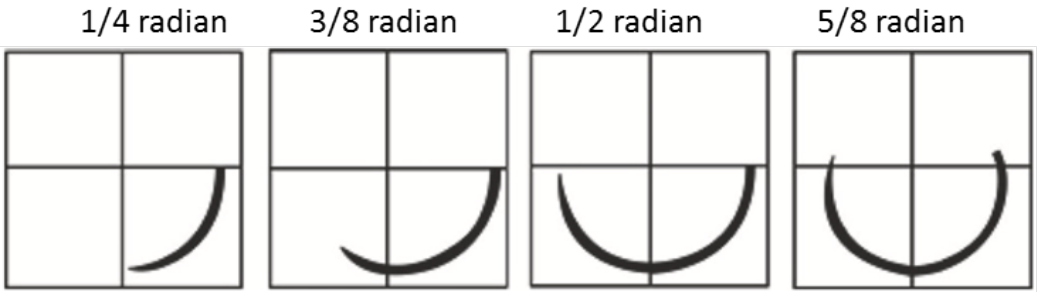


Figure 3A Needle curvatures more used in dentistry (9).

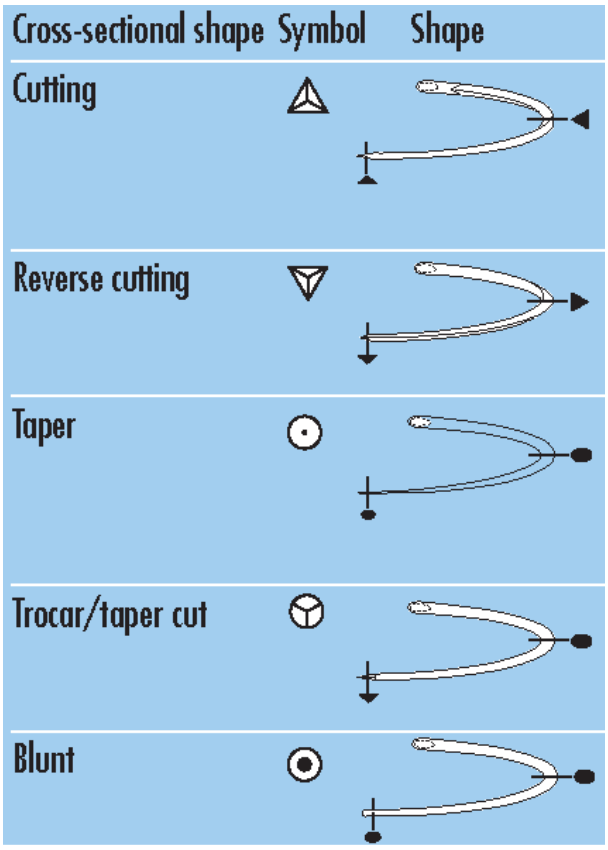


Figure 3B Needle shape, symbol and cross-section (5).

The ideals property of the suture is to keep close the wound for the correct tissue healing until it is removed in another intervention or absorbed by the body. To achieve that purpose, the suture thread as the needle need to use only biocompatible materials to ensure the body will not reject the material placed in it (11). Although the scaring

process is more reduced in the gingiva and oral mucosa in comparison with the skin (12), the dental manufacturers always try to innovate and find new material to suture.

1.3 Historical background of suture

The earliest evidence of treatment with sutured wound comes from Egypt, where there are remnants of surgical equipment comparable to a needle with an eye from 3000 B.C.E. and thread that has been preserved on a mummy's belly from 1100 B.C.E. The Edwin Smith papyrus (dated to 1650 B.C.E) and the Samhita, a surgical treatise by the Indian physician Sushruta, that was written around 600 B.C.E, are the first manuscripts that discuss the use of sutures, 150 years before Hippocrates (6). Then, Hua Tuo (China) and Celsus (in Rome) provided additional descriptions of their use (13). During that time, a large variety of materials were employed, including textile threads, hair, tendon fragments, and intestines coming from animals (14). Later, other descriptions were made by Abu Al-Qasim (Al-Tasrif, circa 1000 C.E.), Henri de Mondeville (Chirurgia, 1306-1320 C.E) and Ambroise Paré (Sur les plaies par hacquebutes in 1543 C.E) who advises, in particular, against cauterizing the arteries in favor of suturing them with a wire (15). In the 19th century, catgut, the first absorbable material derived from the submucosa in small intestine of ruminants, was still the standard suture in use since his first description by Galen in Rome in the second century C.E (13). It had the benefit of being "digested" by inflammatory cells until its complete disappearance. From 1860, its sterilization became an important subject leading to the use of phenol catgut, and later chrome catgut, a material which also had the particularity of being more resistant than the previous one. However, it was not until 1906 C.E that truly sterile thread was offered based on iodine treatment (14). In the 20th century we saw the arrival of the first synthetic threads, Synthofil by B. Braun in 1935 and Supramid by BASF in 1939, as well as the first absorbable synthetic threads, Dexon and Polyglactin 910 (Vicryl), around 1970 C.E. (13). Since Catgut was outlawed at the end of the 20th century as a result of the mad cow epidemic, all sutures are currently composed of synthetic materials, with the exception of those made of silk and steel. There is no longer any used suture material made from animals derivate since the Scientific Committee on Medical product and medical device from the European Commission banned it use and sell in Europe on 16

September 1998. The main reason different materials are still used nowadays for sutures is because most of their physical properties depend on them: tensile strength, elasticity, time to lose 50% of strength or completely disappear from the host organism. From the 1960s, alternative materials such as glues, sticky strips, staples or clips were developed. Clips or staples (metal, plastic, resorbable or not) are sometime qualified as mechanical sutures, but in this review, we will only discuss about wires sutures, not mechanical ones. The sterilization of sutures is now done either by irradiation, by ethylene oxide, by gamma radiations or by heat treatment as autoclave (3).

1.4 Introduction to tissue reaction to suture and cicatrizing

Soft tissue defects (such as wounds, incisions, and wound surfaces) produced by injury or any other reason can be addressed by regeneration, repair, and reconstruction in a sequence of pathophysiological processes known as soft tissue repair or healing. These wounds can be categorized as physical and chemical (like chemical skin injury, thermal burn and radiation skin ulcer), intentional mechanical (like an incised wound or surgery), inflammatory (like an abscess) wounds, which are distinguished by the development of compensatory tissue. In its most basic form, soft tissue healing is a natural defense reaction to a damage and defect of tissues and cells brought on by a variety of pathogenic and trauma-causing events. Soft tissue damage, tissue defects, and tissue loss brought on by necrosis and tissue destruction typically require repair by surrounding histocyte regeneration and rebuilding or by the growth of additional histocytes (mostly connective histocytes) to replace the lost cells (16). The time for a wound to close depend on the skin affected and his localization. In the oral cavity: the gingiva and the jugal mucosa can cicatrize in between some days to weeks for complete healing. In any case, every substance implanted in human tissues, causes some sort of inflammatory response once placed. This reaction is known as “foreign body reaction” and can vary from the simple inflammatory response localized in the area to hypersensitivity and systemic allergic reaction. This difference is influenced by the antigen potential of each material and responsiveness of the host immune system (17). Those reactions can impact both the tissue cicatrizing as well as the systemic health of the patient. The normal cicatrizing process is a pathophysiological sequence that takes

place in four different phases: first the inflammation and cell proliferation in the wound area. Second the epithelialization of the margins. Third the angiogenesis, the neovascularization of the damaged area that contribute to reduce the blood loss by contraction, bring the protective and reparative cells as well as reducing the inflammation. Finally, the remodeling, scaring and healing process happened (18).

Only a few clinical investigations have studied the effects of different suture materials on the inflammatory response and healing. Additionally, there aren't any clinical trials that cover all of the mentioned elements for suture materials in the field of oral surgery in the last 10 years (17). Suture materials have been implanted subcutaneously, intramuscularly, or in the abdominal wall of numerous animals under aseptic settings or with a known number of bacteria to evaluate the natural biologic response to suture materials in general surgery. A great degree of standardization is possible with such experimental models, but results cannot be directly extrapolated to the condition in the oral cavity to humans. In any case, those biological models are used to describe histologically the tissue reaction in vivo. In this case the study used beagles to suture their gingiva after an extraction (19, 20) or rats (21). And more rarely we can see that histological study were made on human (22) with similar results.

In the case of intentional mechanical wound that is sutured, the cicatrizing process is modified. The tissue reaction can be of four different kind: the natural inflammatory reaction with the “foreign body reaction” previously mentioned, an exacerbated reaction known as an allergy or the reaction of absorption (18).

The inflammatory response manifests in the first two to seven days following the tissue’s suture and reflects the tissue reactivity to the suture material. In comparison to natural suture materials, synthetic materials display better behavior toward oral tissues for the tissue inflammatory responses, as stated in several research published in the last forty years (2). This reaction is mainly explained by the microbial adherence to the suture material (17).

It is described with three steps: at three, seven and fourteen days (19, 20) or ten days (22).

At three days (*Figure 4A)*: A fibrin cloth made of polymorphonuclear neutrophils (PMN) and monocytes was present in the initial tissue reaction and leukocytes moved into the suture. Such cells were located between the threads of the braided sutures. It was also seen that bacterial plaque had invaded the suture track. A varied aggregation of inflammatory cells was detected in the peri sutural connective tissue. A dense collection of inflammatory cells, mostly PMNs, was commonly seen just next to the suture channel. They proliferated widely outside of this zone, migrating into the spaces between the collagen fibers and other recognizable connective tissue components. Inflammatory cells were also present outside of these zones, although they were dispersed and less noticeable (19).

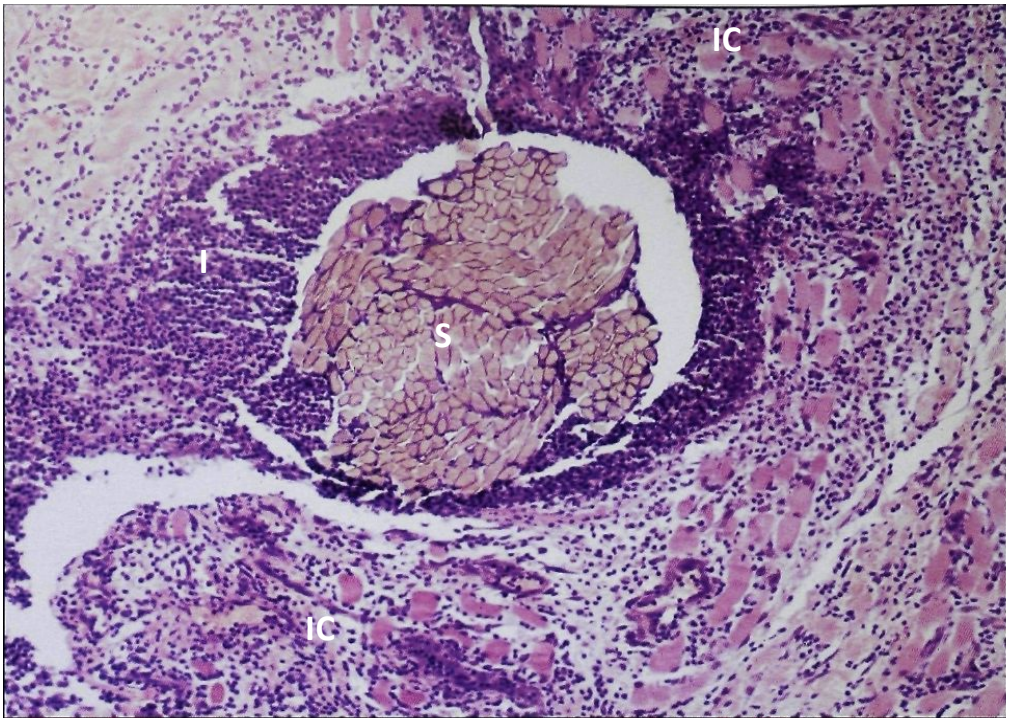


Figure 4A. Early tissue response in silk suture at 3 days includes fine zone of dense cellular infiltrate (I) and zone of inflammatory cells (IC) among identifiable elements of connective tissue. Cellular infiltration among silk filaments can be observed (19).

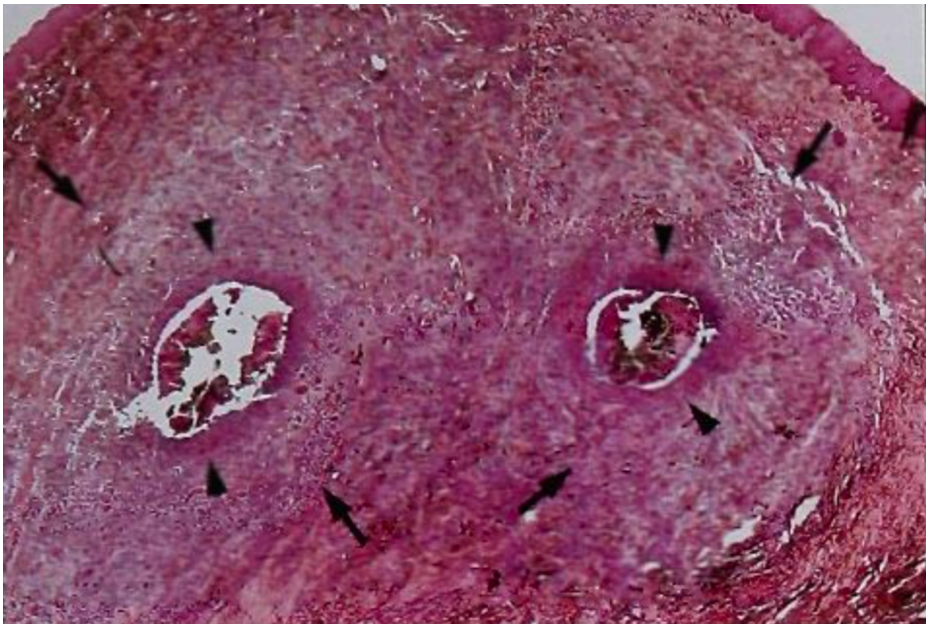


Figure 4B. Perisuture tissue response at 7 days. Each Silk suture is surrounded by dense cellular infiltrate (arrowheads) and by a zone of distinct inflammatory reaction (arrows) that extend from 0.6 to 1.2 mm around the suture track (19).

At seven days (*Figure 4B)*: Suture disintegration: The braided suture materials displayed individual filament spreading and a more significant bacterial plaque invasion in the interstices. Both isolated clusters spread among the suture filaments and thick aggregation around the suture were identified as bacteria. Additionally, compared to three days after suturing, leukocyte penetration was more widespread in both silk and polyglactin 910. Both monofilament and braided sutures had a significant amount of epithelial invagination, and at seven days, several suture loops had been entirely lined with epithelium (19)(17). The two zones previously described at day three *(Figure 4A*) were among the inflammatory responses in the peri sutural connective tissue, which ranged substantially in intensity. The sutures had a significant infiltration of inflammatory cells (20). It seems that less dense inflammatory cell formation in the connective tissue was related to more extensive epithelialization of the area (19).

At ten or fourteen days (*Figure 4C)*: The suture channels in the specimens were epithelialized, and there was a clear presence of a zone of granulation tissue that, in a few cases, had almost completely replaced the zones of inflammatory cell infiltration (22). Granulation tissue may be distinguished from acutely inflamed connective tissue by its reduced cell density, diffuse fiber structure, many capillaries, lighter coloring and layer of encapsulating fibers that surrounds it. Compared to prior observation periods,

differences in tissue reaction across suture materials were more noticeable. Any of the specimens that still had the suture did not have additional remodeling that would have eliminated the granulation tissue (19). Around the sutures, there was a modest amount of inflammatory cell infiltration. There was a little infiltration of inflammatory cells in the epithelium along the sutures. A more pronounced inflammatory reaction was seen for the suture that was positioned on the buccal mucosa in comparison with the keratinized gingiva (20). Particularly in silk samples, there were bacterial plaques around the sutures as well as microorganisms in between the suture threads, a significant number of inflammatory cells in the infiltrate and areas of delayed healing as evidenced by poorly produced granulation tissue. Despite significant cellular invasion, individual suture filaments made in Polyglactin 910 maintained their morphology (19).

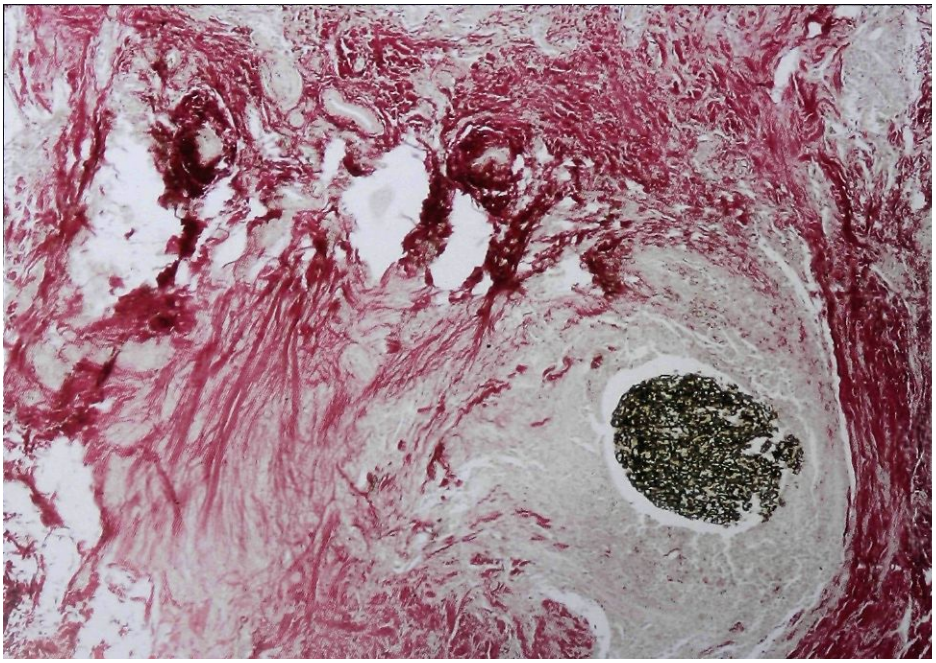


Figure 4C. Tissue repair evidenced at 14 days by peri sutural granulation tissue containing many capillaries without PMNs as well as stained connective tissue fibrils surrounded by encapsulating fibers (19).

1.5 Justification

Among the common practice in dentistry, extractions and surgical procedure represent a routinely acts for 64% of the general dentist, making this the second more frequent act for dentists after the restorative dentistry (23). Thus, it's a capital field to investigate and improve in our daily practice.

The objective of this work is to increase the current knowledge about dental suture material and their tissue reaction. We will compare the biocompatibility, inflammatory response levels and the effect on wound healing of the three suture materials mainly used in oral surgery. We will not talk about bacterial colonization as we will focus on the pure tissue reaction induced by each material itself.

The field of dental suture is essential because of the large dental procedures where it is used; from the periodontal surgery to the soft tissue suturing around implants. It has also esthetics repercussions as dental surgery can leave scars. Indeed, after an extraction or any other dental surgery, the functional disturbance as well as the inflammation process in the area and aesthetic appearance of the gingiva with the suture thread placed can be difficult to bear for patients. Thus, it's our responsibility to diminish this inconvenience for the patient by choosing the best material possible with the less tissue reaction. In the objective for dental surgeon to minimize the adverse reactions and scaring of the tissue, we need to compare the different materials more used nowadays in dental practice: the silk, nylon and polyglactin, as well as the needles used, to find the best material for gingival suturing to achieve an esthetic result of the scars and pleasant healing of the wound.

2. OBJECTIVES

Main Objective: To establish the best suture material to use in the gingival surgery to achieve an esthetic result and minimize the tissue reaction.

The secondary objectives are:

a. To compare the tissue reaction between monofilament and multifilament.

b. To find the ideal diameter of the suture filament.

c. To find the needle appropriated for each procedure.

3. MATERIAL AND METHODS

Articles were searched in MEDLINE complete and Google scholar using the following words: Suture/ Tissue reaction/ Adverse reaction/ Foreign body reaction/ Wound/ Silk/ Nylon/ Polyglactin 910/ Vicryl/ Suture needle/ Scars/ Suture diameter/ Dentistry/ Oral/ Gingival/ Guidelines/ Guide/ Protocols

On Medline complete we used the following 3 research equations:

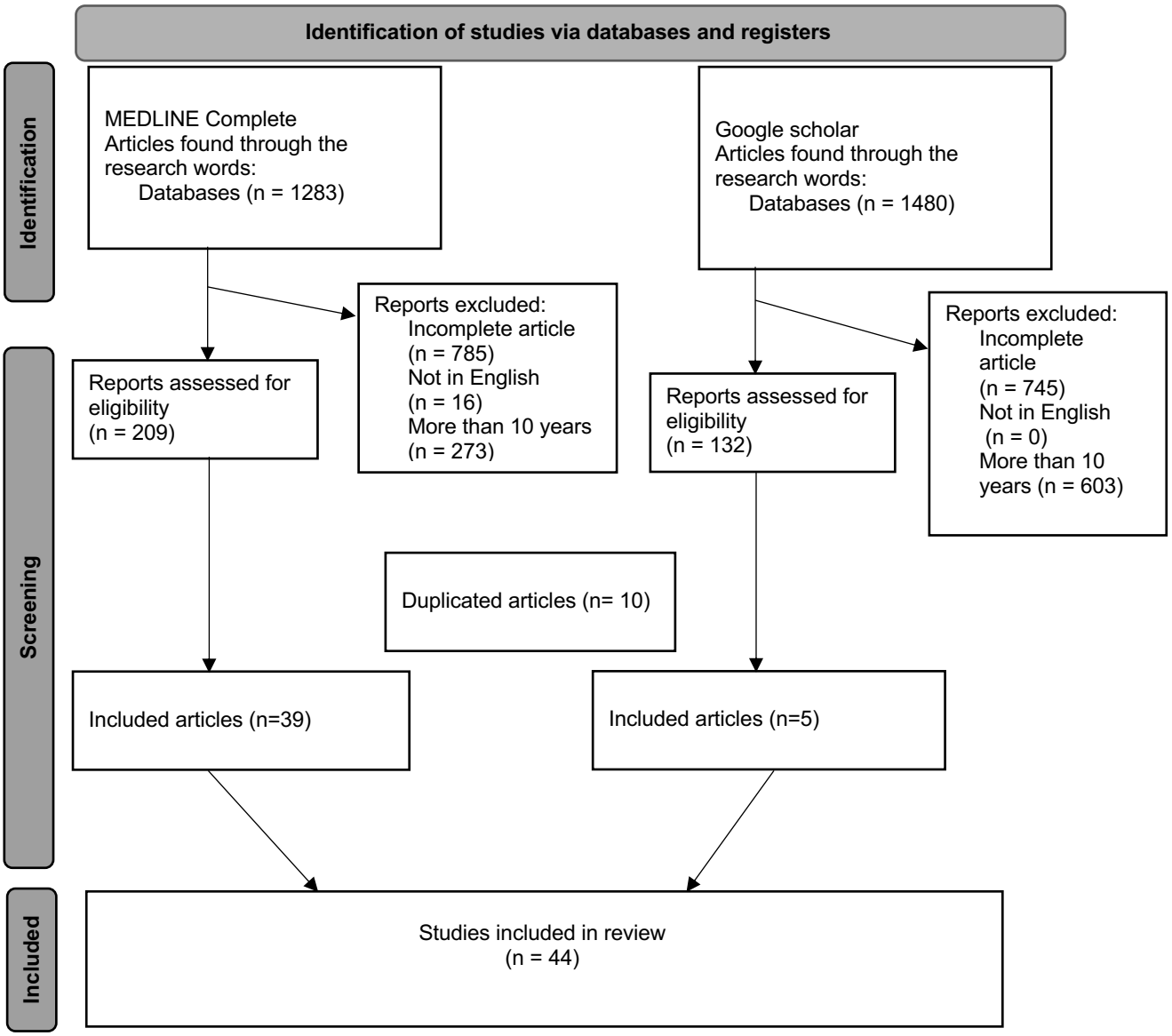
- (((((suture) AND (tissue reaction)) OR (foreign body reaction)) AND (polyglactin 910)) AND (oral)) OR (nylon)
- (((((suture) AND (tissue reaction)) OR (foreign body reaction)) OR (polyglactin 910)) AND (oral)) OR (nylon) AND (Silk)
- (((suture) AND (tissue reaction))) OR (suture needle) AND (oral)

The articles have been chosen based on different criteria:

- Exclusion of the research of articles not entirely available or that have been duplicated.
- Articles must be written fully in the same language for being considered.
- Selection of articles published only in English scientific literature or books, relevant for the topic, published within the last 10 years.

Articles have been all captured into Zotero for citation references. After a careful investigation of different articles, we have mainly focused our study on three suture materials selected: silk, nylon, polyglactin 910 and their tissue reaction only, because they presented much more scientific evidence in the medical literature and they are more relevant for dentistry uses and applications. By applying the different criteria of selection, we have used 44 articles mentioned in the bibliography.

4. RESULTS AND FLOW CHART



Title	Year	Study	Subjects	Type of procedure	Suture material used	Main results/conclusions
COMPARISON OF FOUR DIFFERENT SUTURE MATERIALS IN RESPECT TO ORAL WOUND HEALING, MICROBIAL COLONIZATION, TISSUE REACTION AND CLINICAL FEATURES (17).	2020	Randomized clinical study	Human	Oral surgery	Silk, polypropylene and polyester	The least concluding results of soft tissue healing was seen around non-resorbable silk suture: a stronger inflammatory response was generated and a greater affinity to microbial adherence. Polypropylene show better result among all the sutures (17). Following oral surgery procedures in clinical situations the monofilament synthetic suture types showed higher effectiveness (17).
HOW DO ABSORBABLE SUTURES ABSORB? A PROSPECTIVE DOUBLE-BLIND RANDOMIZED CLINICAL STUDY OF TISSUE REACTION TO POLYGLACTIN 910 SUTURES	2014	Randomized clinical study	Human	Eyelid surgery	Polyglactin 910	Polyglycolic acid sutures provoke a significant foreign body inflammatory response proportional to suture size. An early suture removal can minimize this reaction. The study confirms an innovative and ethical approach to the examination of human skin behavior to implanted suture material (24).

IN HUMAN SKIN (24).						
SUTURE MATERIALS AFFECT PERI-IMPLANT BONE HEALING AND IMPLANT OSSEOINTEGRATION (26).	2015	Randomized experimental	Animal model	Oral implant surgery	Nylon	Sutures may influence early peri-implant healing if filaments are left in close proximity to the bone/implant interface. Added study are necessary for determining the impact of more sutures materials on peri-implant bone healing (26).
ANALYSIS OF TISSUE INFLAMMATORY RESPONSE, FIBROPLASIA, AND FOREIGN BODY REACTION BETWEEN THE POLYGLACTIN SUTURE OF ABDOMINAL APONEUROSIS IN RATS AND THE INTRAPERITONEAL IMPLANT OF POLYPROPYLENE,	2021	Experimental	Animal model	Abdominal surgery	Polypropylene, polyglecaprone and polyester/ porcine collagen meshes.	The intraperitoneal implantation of meshes, particularly tissue separating meshes made of polypropylene/polyglecaprone and polyester/porcine collagen, presented a stronger and longer tissue inflammatory response compared to repairs with polyglactin suture in the musculoaponeurotic area. Moreover, the groups with meshes had a more immature and disorganized fibroplasia, characterized by a decrease in the tissue proportion of type I/III collagen, and a greater foreign body reaction. But, no major differences between the polypropylene mesh group and the

POLYPROPYLENE/POLYGLECAPRONE AND POLYESTER/PORCINE COLLAGEN MESHES (27).						groups with tissue separating meshes (27).
INDUCTION OF IMMUNE GENE EXPRESSION AND INFLAMMATORY MEDIATOR RELEASE BY COMMONLY USED SURGICAL SUTURE MATERIALS: AN EXPERIMENTAL IN VITRO STUDY (28).	2017	Experimental	In vitro		Silk, Polyglacting 910 (Vicryl), Polyester and Nylon (Ethilon)	Four commonly used suture materials produced upregulation of pro-inflammatory markers revealing an early external body reaction, with no balance from anti-inflammatory markers. As known, long early pro-inflammation produces delayed wound healing responses, the information provided by this study allow to improve surgical decision making and patient safety, by reducing suture-related adverse immune reactions, and then positively affect patient outcomes (28).

PROSPECTIVE COMPARISON OF PRIMARY WOUND CLOSURE WITH TISSUE-ADHESIVE VERSUS SUTURE MATERIALS (29).	2015	Clinical study	Human	Skin surgery	PGA, polypropylene and adhesive (octylcyanoacrylate)	Tissue adhesive is effective and reliable in primary skin closure, given similar cosmetic results to standard suturing method. Tissue adhesive is faster and provides many practical benefits over suture repair (29).
A CLINICAL STUDY ON THE INFLUENCE OF SUTURING MATERIAL ON ORAL WOUND HEALING (30).	2015	Clinical study	Human	Oral surgery	Catgut, Dexon and Vicryl rapide	The faster wound healing was obtained with Vicryl rapide. No main difference regarding local reaction in all the three groups of patients on the 21st postoperative day (30). Better contribution of the Vycril-rapid than catgut or Dexon to faster healing of human wounds, with fewer incidences of wound dehiscence and milder local reactions (30).
EFFECTS OF DIFFERENT SUTURE MATERIALS ON TISSUE HEALING (32).	2016	Experimental	Animal model	Back surgery	Silk, polypropylene, coated polyglactin 910 and polyglecaprone 25	For surgical practice, there is no only one ideal suture material. The choice of an appropriate suture material lays on patient characteristics, the type of the surgery and the quality of the tissue (32).

EFFECT OF DIFFERENT SUTURE MATERIALS ON WOUND HEALING: A CLINICAL STUDY (33).	2016	Clinical study	Human	Oral surgery	Catgut, Dexon and Vicryl rapide	For application in oral surgery, Vicryl rapide presents the best properties of all available absorbable suture materials. Better contribution of Vicryl rapide than catgut or Dexon to faster healing of human wounds, with fewer incidences of wound dehiscence and milder local reactions (33).
PERFORMANCE EVALUATION OF NEWER TYPES OF SILK SURGICAL SUTURES (34).	2018	Clinical study	Human	Oral and eyes surgery	Silk and cyanoacrylate glue	Tests were made with different textile materials. In one clinical study, Polyglactin 910 sutures were linked to the expansion of stitch abscess. Tissue reactions are minimal with nylon sutures. Studies between silk sutures and cyanoacrylate adhesive has demonstrated that the use of cyanoacrylate produced less postoperative inflammation and good clinical and histological healing compared to the silk sutures. But, from a programmatic perspective, polyglactin-910 presents the major benefit that no patients examination is needed after the surgery for suture removal (34).

SUTURE MATERIAL - IT'S IMPORTANCE IN WOUND HEALING (35).	2015	Clinical study	Human	Head and neck surgery	Vicryl/ Ethilon, Vicryl/ Mersilk, Catgut/ Ethilon, Catgut/ Mersilk	Due to the use of unique suture material, 23.8% present poor wound healing. The use of Catgut and Mersilk in deeper and superficial layer provided the worse healing, up to 40%. With less than 8% of bad healing Vicryl in deeper layers and Ethilon in superficial layer seemed to be the best solution (35).
PREFERENCE OF SUTURE SPECIFICATIONS IN A SELECTED PERIODONTAL AND IMPLANT SURGERIES IN TURKEY (36).	2019	Research survey	Human	Oral surgery		In periodontal and implant surgeries, dentists favor using nonabsorbable sutures. Moreover, the shape and diameter of needle had a significant function in the choice of suture material. Those study's results form a solid basis for the next studies (36).
EVALUATION OF MECHANICAL PROPERTIES OF THREE COMMONLY USED SUTURE MATERIALS FOR CLINICAL ORAL APPLICATIONS:	2022	Experimental	In vitro		Silk, polyglactin 910 and polypropylene	This study confirms that the suture materials tend to lose an important rate of tensile strength in an oral environment. The polypropylene sutures showed highest mechanical properties when compared to the polyglactin 910, and silk suture. The authors establish a ranking of suture material for wound closure after oral and periodontal surgeries: Polypropylene is the best, followed

AN IN VITRO STUDY (43).						respectively by polyglactin 910 and silk (43).

5. DISCUSSION

5.1 Suture material

Many suture materials are accessible for dental surgical operations nowadays. Nevertheless, surgeons must be aware of the biological processes of healing, the nature of the suture material and the interaction when placed with the surrounding tissues (2). For the gingiva, in esthetic areas excellent aesthetic results were obtained in 80.3% in the sutured wounds whereas it's only in 77.3% of the tissue using an adhesive. Thus, advise the use of suture for an esthetic result instead of adhesives tapes in the oral mucosa (29) but study point out the need to select the appropriate suture material for each oral surgery (2).

As described previously, the tissue reaction to suture material include the natural inflammatory reaction also called the "foreign body reaction", an increased abnormal reaction known as an "allergy" or the reaction of absorption in the case of resorbable suture. The last one is described for the Polyglactin 910 also called Vicryl in the commercial name. Since the early 1960s, polyglycolic acid (PCA), a durable, fiber-forming polymer, has been utilized to create synthetic absorbable sutures, it's the base component of Polyglactin. Glycolic acid is produced when PCA is hydrolyzed in the ester bonds in it chemical formula (6). It is then, subsequently eliminated in the urine or go through the tricarboxylic acid cycle to produce carbon dioxide and water in the body (24).

Absorbable material can also be disintegrate by enzymatic degradation in the tissue but it's only for natural absorbable materials as the more recent synthetic absorbable sutures are absorbed through non-enzymatic hydrolysis (25).

To this day, research evidence on the efficacy of various materials is disputed and contradictory (2). There is no suture that is superior to the others in every way. The variations in tissue reactivity and bacterial adherence between sutures should always be addressed while choosing the best suturing material for each case (3).

Nevertheless, silk is the most commonly used suture material in dentistry worldwide. Despite the fact that silk is less costly and easier to handle than other nonabsorbable

suture materials, the authors concluded that it can't be called the "material of choice" for oral surgical treatments. In fact, studies on oral tissue reactions to sutures have indicated consistent inflammatory reactions, which are more pronounced with silk and less pronounced with nylon, polyglactin and other PGA derivates in multiple research conducted over the last 30 years (2).

Some histological examination and clinical study, showed that silk caused longest and more intense inflammatory response due to its structure, that is multifilament, which works as a great bacterial receptor (2, 17, 31). Soft tissue healing was shown to be the worst surrounding non-resorbable silk suture than around any other suture (17).

Histological study revealed the traces of a lot of neutrophilic polymorphonuclear leukocytes in the zone of silk sutures, which were less intense in oral tissues further away from the sutures. Another discovery was that fibroblasts and new capillaries grew at a lower speed in oral tissues near silk sutures than in tissues further away from the silk sutures. This might explain the gradual healing and severe tissue responses linked to silk sutures (2).

Bacterial adhesion to multifilament silk sutures was five to eight time greater than to nylon, which had the least quantity of germs adhering. Because of their propensity to facilitate bacterial migration into the flap, multifilament silk sutures generate more broad inflammatory response than monofilament sutures (2, 36).

When using in vitro models, Silk suture materials induce activation of pro-inflammatory marker genes early in the foreign body reaction (28). Thus, indicating that the reaction to silk is rapid and intense once placed in the wound.

Silk sutures required less intraoperative handling and caused less discomfort in the patient (36), explaining it wide clinical use.

Nevertheless, the choice of suture material for periodontal or implant surgery is frequently dependent on personal preferences rather than scientific evidence and has not been well researched. Several factors influence dentists' suture choices in each clinical circumstance, including soft tissue quality and thickness, flap design, and

personal preference. Among the choices, nonabsorbable and monofilament sutures were strongly favored in all periodontal and implant operations (36). Moreover, because of its greater operability, surgical silk has become the global standard in studies, by which surgeons evaluate the performance of new synthetic materials in comparison to silk (9).

For example, once nylon, a polyamide polymer suture, has been chemically developed, it has been compared to silk (9). Nylon caused the least inflammatory response, with earlier tissue repair (2, 17) because it showed the lowest level of bacterial accumulation of any suture material tested (31).

Nylon is the most widely used non-resorbable suture material. Nylon sutures, which can be monofilament or braided, have a minimal inflammatory response in infected wounds (37).

Nylon, because of its monofilament structure, is ideal for wound suture in skin. In the human body, nylon sutures hydrolyze at a rate of 15-20% every year. Because monofilament nylon suture has a propensity to return to its original straight state, condition known as " material memory", more knots must be tied than with braided silk suture to assure safety (9).

When using in vitro models, Nylon (Ethilon) sutures stay relatively inert without inducing activation of any pro-inflammatory marker genes, indicating that nylon doesn’t provoke a rapid foreign body reaction (28).

Although there have been reports of minor tissue responses to nylon (2), it can nevertheless result in a foreign body tissue reaction in some rare cases (26).

According to this study, we can conclude that monofilament synthetic suture as nylon should be utilized whenever feasible to provide the best soft tissue recovery, reduce the risk of postoperative infection, and relieve suturing following oral surgical operations (17).

In contrast, for gingiva suture around implant implants, suture materials can influence bone resorption and inflammation, and different materials may have varying impacts on these processes (37).

Nylon suture demonstrated a tendency toward “decreasing implant attachment” in only one study. Therefore, increased bone resorption at the bone-implant contact may explain the decreased implant retention shown with the nylon. The osseointegration process occurring at the bone/implant area may be delayed by the presence of non-resorbable filaments as well as the characteristics of the nylon sutures (26). Thus, advise for absorbable material around implants.

But another study advise for the use of non-resorbable suture as nylon around implant because resorbable suture decrease implant retention due to the increased bone resorption it produce (37).

One of the alternatives in absorbable synthetic sutures is the polyglactin 910 also known as Vicryl. The Polyglactin 910 sutures have a retention time of 28 to 35 days and an absorption rate of 56 to 70 days in the human gingiva (6). PGA, which is the base component of the polyglactin was manufactured to produce a limited inflammatory reaction (31).

When using in vitro models, Polyglactin 910 induces an activation of pro-inflammatory marker genes early in the foreign body reaction as the silk (28). In general, absorbable sutures, removed 1-2 weeks postoperatively, elicit more local responses in healing tissue than non-absorbable sutures, resulting in higher scarring. Moreover, if a wound is actively infected, it should not be closed because buried absorbable sutures can become an infection foci (5). But because we don’t usually suture infected wound in dentistry, this argument can be discarded.

When using animal models such as rats, the use of suture made of Polyglactin have produced a “more reduce and shorter” inflammatory tissue reaction in comparison to non-absorbable synthetic suture materials such as the polyester or nylon (27).

Based on this study, polyglactin 910 should be the material of choice for suture in dentistry. In fact, it has shown to be physiologically great since it prevents plaque adhesion and allow for a simple and fast passage into tissue with minimal resistance. Furthermore, doesn't produce any intense local response. It only disadvantage might be the potential of knots loosening. But this weakness can be solved by tying additional knots (30). Polyglactin 910 when coated, under the commercial name Vicryl Rapide, appears to have the greatest qualities of the existing absorbable suture materials to use in the oral cavity. It promotes quicker recovery of human wounds, with lower risks of lesions dehiscence and less inflammatory reaction (30, 33).

From a programmatic point, polyglactin 910 has the main benefit of not requiring patients to do a check-up immediately after operation to remove the suture, which is useful in many situations in clinic or in hospital (34).

For deep wounds; a combination of Polyglactin 910 in the deeper layers and nylon in the outer layers seems to be the optimum, with just 8% of poor healing due to mild tissue reactivity (35).

Nevertheless, it is suggested to remove those sutures quickly following surgery, regardless of whether the suture is absorbable or not because of the constant interaction within the complicated oral flora (32). But because the soft tissue healing was much better around all sutures at one week postoperative than on the third day, the writer of this study advise to always keep sutures in place for 7 days rather than removing them sooner (17).

Numerous studies have shown that absorbable sutures, due to their metabolization with enzymatic digestion and phagocytosis, would induce higher body response than non-absorbable materials, which create merely a blind inflammatory response (37). However, no substantial difference in tissue reactivity to absorbable and non-absorbable suture was identified in only one research (32).

5.2 Filament structure

The choice of suture material for implants or periodontal surgery is frequently dependent on own preferences instead of scientific evidences. Several factors influence dentist's suture choices in each clinical circumstance, including soft tissue quality and thickness, flap design, and personal preference. Among all the choices, nonabsorbable and monofilament sutures were strongly favored in all periodontal and implant surgery (36). It is imperative that a surgeon develops their own personal choice of suture so familiarity and experience translates to reproducible results (1).

Suture selection in periodontology should be based on the demands of the repair process as well as the surgeon's expertise and experience but point to the use of synthetic monofilaments sutures (37).

Several investigations have demonstrated a lower inflammatory response after using monofilament suture materials in oral wounds over multifilament ones (1, 32, 38). Whether resorbable or not, monofilaments exhibit little bacterial adherence or growth and are thus preferable from an histological and biological point of view (1, 2, 31, 38). Monofilaments have a smooth surface which facilitates their use and their passage through the tissues is not very traumatic because of their little friction. However, they have a rigidity that makes them less manageable, have sharp point that irritate the mucosa, and knot are weak (38, 32). Monofilaments decrease postoperative comfort by injuring soft tissues with their tip making them less preferred by the patient and the dentists (38).

For the same suture diameters, the failure load of monofilament sutures is larger than that of multifilament sutures (39). Thus, indicating monofilament suture are more deformable than multifilament before breaking. Monofilament sutures provide less resistance to tissue and close wound more easily. On the other hand, they must be handled with care since they might weaken or break when squeezed by certain equipment. Greater tensile strength, flexibility, and pliability are provided when many strands are braided together to produce the multifilament suture (1).

Although braided sutures offer certain advantages over monofilament, such as easier manipulation and increased knot stability, they nevertheless have a considerably higher risk for infection transmission (36, 37). Due to their rough surface, it promotes bacterial development and causes more and more friction as it passes through the tissues (5, 38). By capillary action, multifilament sutures enhance bacterial adhesion to sterile sites and so accelerating the infection process of wounds (5, 32). Thus, infected wounds or those at high risk of contamination should be sutured with non-absorbable monofilament sutures (5, 17). To provide the optimum soft tissue healing and relieve suturing following oral surgical operations, monofilament synthetic suture is strongly recommended (17).

In regenerative surgeries, for mucogingival surgery and for dental implants, monofilament are preferred by the dentist (36).

5.3 Suture thread diameter

For Silverstein, it is critical that the dentist choose the appropriate suture thread and the diameter of it. We need to consider the width as well as the presence or absence of tension-free mobile tissues (37).

The diameter has been defined as increasing the number of zeros make the diameter smaller. As the diameter lowers, the suture weakens (3, 40, 42, 43) and opposite the tensile strength increase with it diameter (5). For example, the 4-0 sutures surpass 5-0 sutures in terms of tensile strength (31, 42).

Adequate strength is critical when selecting suturing material. Surgeons should select a material with a greater strength-to-diameter ratio, stable diameter, sterility, pliability, excellent tissue acceptance, and function predictability (25).

Whether the wound is single or multilayered, the lowest suture size or diameter that will achieve the task should be chosen, limiting both tissue stress with each needle passage and the amount of foreign material left behind. But as smaller-diameter sutures have lower tensile strength, therefore a compromise must be achieved between suture

size and force necessary for tissue closure (1, 42) as well as the predicted stress on a suture wound (25).

Taking in count that the level of local reaction is related to the quantity of suture material set in the wound, the tensile strength of the suture material must be slightly larger than that of the tissue with the lower diameter possible (3, 42).

Most intraoral procedures employ diameters in the 3-0 to 4-0 range (40, 43) because it bears the dynamic forces such as those seen in the oral cavity (42). Sutures of size 3-0 are big enough to sustain intraoral strain and robust enough to allow easy knot tying with a needle holder than thinner sutures (40).

Sutures with a narrower diameter may be useful in minimizing tissue trauma (41) since thinner sutures, as 6-0 and 7-0, cause thread breaking rather than tissue tearing and rupture (38).

In regenerative surgeries and mucogingival surgery the diameter 5–0 was preferred. On the other hand, for dental implants, the diameter 4-0 was preferred by the dentists (36). Another source stare that 4-0 is most typically used in periodontal flap procedures, whereas 5-0 is primarily utilized for fragile tissues and soft tissue graft surgery (3).

At two weeks postoperative, the thread of polyglactin 910 loose about 35% of rigidity. The tensile strength of diameter 6-0 and beyond is around 40%, 21 day after suturing, whereas the 7-0 or thinner suture is approximately 30% (9). Thus, thicker suture kept their tensile strength longer after placing it in the oral cavity.

5.4 Suture needle

The last parameter to select once we have chosen the suture is the needle. It design and diameter have a capital impact when electing the suture material (36). Surgeons and dentist approximate tissues daily, but their suture and needle selection is mainly influenced by what they learnt in training or by unpleasant events in their careers (1).

This empirical choice should be replaced by an evidence-based choice (36) that is more accurate and adequate for each procedure.

When the dentist selected needle specifications for each operation, reverse cutting and 3/8 curved needles were always the most preferred (36, 45). As a result, instead of selecting a different suture and needle for each treatment, they employ the same one for all of them.

All sutures are now packed and mounted on needles, a process known as swaged on. Cutting needles are preferred for robust tissues like skin, whereas tapering needles are preferred for more fragile tissues like the intestine. The curved 3/8 cutting needle is the most often used for skin closure (45).

When comparing monofilament and multifilament sutures they were all selected with reverse cutting needles (20).

Cutting needle tips are suitable for coarse tissues or atraumatic penetrations. Sharp needles, such as reverse cutting needles are indicated to limit tissue stress. The needle's form might be straight or curved to varying degrees. The 3/8 circular needle is mainly recommended for periodontal treatments. The needle length, which is measured along the needle curvature from the tip to swage, varies greatly. For interproximal sutures needle lengths from 13 to 15mm are adequate for posterior area and 10-12mm suits for the anterior. Needle lengths ranging from 5-8 mm are sufficient for closing buccal-releasing incisions. To ensure perpendicular penetration into the soft tissues and minimize tears, a curved needle is effective in regions where minimal penetrations is needed, such as the base of the papillae (38).

Because the mouth cavity is a small place, needles with 3/8 or 1/2 circle curves are advised. The 3/8 curved is indicated for dental surgical operations since it is easier to utilize with simply a wrist movement from vestibular to lingual. However, the 1/2 curve needle can be effective in the deepest area in the mouth or with thinnest sutures as the 6-0. To suture the oral mucosa and the palatal one a reverse cutting needle or a taper-cut should be used. The taper-cut have a cutting tip with a round body that lessened

tissue stress. Taper-cut needles are ideal for suturing more fragile thin gingival tissues but for muco-periosteum cutting needle are mandatory (39).

Suturing general guidelines include the following recommendations: When space is limited, use a 1/2 circle needle (37).

In the oral cavity, the most typically used needles are 3/8 circular. They are simple to use in big and superficial wounds and require little wrist movement. Suturing tissues in minor wounds, bodily cavities, and orifices use a 1/2 circle needle. Less space is necessary, but more movement of the wrist is required. Cutting needles are excellent for suturing keratinized tissues such as the palatal mucosa and anchoring drains. Round or tapered needles used to puncture soft, readily penetrated mesenchymal layers like muscle or fascia. Tapered points are often utilized on soft tissues. It leaves a tiny hole and can be utilized in both vascular and face soft tissue surgery. The rounded end of the blunt tip prevents it from cutting while passing through (3).

For the best maneuverability, we have to prefer the shorter and the more curved needle. In general, cutting needle tip with a triangle symbol on package, is the best to suture epithelial wounds. The kind of needle tip used is determined by the thickness of the tissue being sutured (5).

5/8 radian taper needles are the more suited for dental suturing because it reduces tissue injury in order to achieve fast tissue regeneration and minimal scar formation. Reverse cutting needle were particularly developed for difficult-to-penetrate tissues such as in the oral cavity (9).

In the different study all the compared sutures have a 3/8 circle reverse cutting needle (17) or round body needles as the tapper-cut (7).

A little 1/2 or 3/8 circle suture needle is typically used to close oral mucosal incisions. The needle is bent to fit through a small opening that a straight needle cannot, and passage is accomplished by rotating the wrist (40).

A right balance is based on needle hardness and elasticity. When encountered with resistance, a needle that is excessively hard may break, whereas one that is too flexible may not precisely exit to the desired place. Conventional (cutting) and reverse cutting needles are the two main cutting needles used in dentoalveolar surgery. Both contains three cutting edges. The conventional cutting needle has a third edge that faces up, toward the interior of the circle, whereas the reverse cutting needle has a third edge that faces down as seen in *Figure 3B*. Reverse cutting needle or taper-cut should be favored in oral cavity. The first one being more stable in the needle holder due to it shape (44).

6. CONCLUSION

- Suture is the main act made in most of all dental surgery. Nowadays dentist select their material based on their experience, not on the more recent research as it's should be for evidence-based dentistry. In fact, black silk is the most used suture due to low cost and easy clinical use. Based on the more recent researches, black silk should not be the gold standard anymore in dentistry.

- Due to its multi stranded structure and its natural material black silk is more susceptible for plaque accumulation and tissue inflammation than monofilaments. Instead, dentist should now base their use on the more recent results. They all point out to use monofilament synthetics material such as Nylon or multifilament synthetic as the Polyglactin, to reduce at maximum the tissue reaction and not produce scars after surgery. A combination of both can be utilized, Polyglactin 910 in deep layers and Nylon in superficial ones.

- Once selected the material, the diameter of the suture should be chosen. The ideal diameter is always the thinnest possible in comparison to the tissue strength and thickness. In fact, the diameter ranges from bigger 3-0 for thick tissue, as the palate or the gingiva in area submitted to stress, to thinnest 4-0 or 5-0 in more delicate procedure in the gingiva as around implant or esthetic areas in the oral cavity.

- Finally, the needle has to be selected. The needle should pass through the tissue but not damage it or tearing it, thus it should be a triangular cutting needle tip; with the base toward the wound, they are called reverse cutting or with a round body, they are called taper-cut. The second one being less stable in the needle holder. Both reduces oral tissue reaction. Due to the narrow space and the movement needed to pass from vestibular to lingual we need to use curved needles in the oral cavity. The curvature used ranges from 3/8 to 1/2 circle, the first one being preferred because it has more maneuverability as well as a good penetration with just a swing wrist movement from vestibular to lingual or palatal.

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